Cascading Crises: Orbital Debris and the Widening of Space Security[*]

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The term "space security" is often used, but seldom analyzed. This is a significant gap in the literature of space politics as it could have considerable implications for debates on how to deal with a runaway growth in the space debris population, and how we argue for or against space weaponization. Securitizing all threats in space may lead to greater difficulties in enacting debris removal measures as these systems are inherently dual-use. A case is made for keeping space security in its traditional connotations of national security so that environmental issues related to orbital debris can be resolved with reduced security concerns in a space development framing.

Space is a strategically vital geography for any modern military-economic power. Force enhancement, network-centric warfare, precision-guided munitions, accurate navigation and treaty verification would be impossible without the help of satellite systems. The United States' dependence on space systems for its military power, and the space-dependent global economy, makes any danger to satellites a pressing concern. As well as the threats that may be posed by other space powers, space debris will grow to pose a significant risk to space operations in the decades ahead. As research and development progresses on ways to remove debris, these removal systems could be caught up in the deadlock on space arms control if orbital debris is seen in terms of a security issue. This paper uses the problem of orbital debris to argue that 'security' should remain within the traditional purview of 'strategic studies,' and non-military, non-violent, or non-human risks should not be given the label of "security threats."

There are two cascading crises at the meeting point of security and the space environment. The first is that the orbital debris population may cascade out of human control in the decades to come, known as the Kessler Syndrome. Secondly, a cascading and seemingly unstoppable widening of the definitions of space security is occurring in academia to include every hazard as a security threat to satellite systems and national security. These cascading crises raise questions. Should orbital debris be considered a security issue for the United States? Does a wider definition of space security offer greater risks of negative international reactions for dealing with space debris rather than a narrow, or traditional, definition of security in space? If space debris is considered a national security issue, will the United States trigger a political backlash against such a dual-use system as active debris removal (ADR)?

[*] Post-print copy, article published as: Bleddyn E. Bowen, 'Cascading Crises: Orbital Debris and the Widening of Space Security', *Astropolitics: The International Journal of Space Politics and Policy* (12:1, 2014) pp. 46-68
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First, it is shown how orbital debris is not a minor problem for anyone dealing with contemporary space affairs, be they strategists, political scientists, lawyers, engineers or scientists. Thereafter, competing concepts of security are elaborated. These two concepts' impasses over the issue of space debris are then addressed by invoking the utility of the traditional concept of security in space matters so as not to politically endanger ADR systems that are on the horizon. There is no extensive policy prescription, only a recommendation that certain risks in space are best considered in certain ways, lest unwanted international political repercussions occur. This is a challenge to the acts of securitization seen in academia and how it may adversely affect a very serious problem that modern human civilization has to face if it wishes to continue to use outer space.

POLICY

It is important to know what the United States is thinking about space as it is our referent object of security for this argument, and upon inspection some non-military risks to U.S. national security appear to have been or are close to being securitized. This warns of the potential that the environmental hazards of space could be securitized in U.S. policy, and academic widening of security may exacerbate this risk. A caveat must first be mentioned: these documents can be taken as one of the outcomes of the push and pull of bureaucratic politics and the aggregation of public and private interests.[1]

U.S. policy documents at the meeting point of space and security mostly refer to national security. The 2010 National Space Policy (NSP) interprets the "peaceful purposes" of space to include "national and homeland security activities" – this is nothing new.[2] The 2010 NSP also presents a desire to minimize risks in orbit, such as debris mitigation and space situational awareness (SSA) improvement.[3] It wishes to utilize national security space assets, in accordance with foreign powers "if necessary," to "detect, warn, characterize and attribute *natural and man-made* disturbances to space systems of U.S. interest."[4] Disturbances, such as solar storms and debris, are not explicitly referred to as security threats to space systems of U.S. interest. This notion of disturbance is in contrast to the definition of space security as proposed by the *Space Security Index*, which defines space security as "the secure and sustainable access to, and use of, space and freedom from space-based threats."[5] Here, solar storms and debris can easily take on the emotive exceptional notion of threat, as opposed to everyday routine potential of disturbances.

It may be that what the United States sees as the most pressing danger to its space systems is that of intentional attack from another actor, as opposed to unintentional dangers, such as environmental degradation or turbulent solar storms.[6] U.S. national security priorities are nuclear proliferation and (jihadi) terrorism. Space provides crucial support roles in addressing these security issues. However, there is a linking of security to broader non-military issues such as food security, global health, sustainable development and climate change, as well as a hint of a deepening of security to the global level as "the United States of America will continue to underwrite global security."[7] These examples show that the broadening and deepening of security, whilst in no way absolute, is present to varying degrees within U.S. policy making and

public communication. This is a cause for concern with the potential to make orbital debris a security issue.

The United States believes it is operating in a "congested, contested and competitive" strategic environment in space.[8] Space debris is given the opening shot of the National Security Space Strategy's (NSSS) chapter on the strategic environment of space. The NSSS cites the competition over radio frequency slots as a congestion issue.[9] Also, it hints at the possibility of adopting a Code of Conduct for promoting safe practices in space.[10] As far as the NSSS is concerned, a condition of security does not necessarily follow from mitigating debris and resolving frequency slot allocation issues. We can ascertain that there is no overt case of linking notions of security with non-military problems, like orbital debris or solar storms. The latest update to U.S. space policy adheres to this analysis.[11] Yet, there are timid forms of broadening and deepening security present.

SPACE DEBRIS AND REMOVAL

Space debris is an umbrella term taken to mean any human-made object that is up in orbit, which does not serve a useful purpose. A precise and agreed upon global definition of debris objects does not exist.[12] Every launch into orbit creates debris – such as defunct or unused satellites, spent rocket stages, detached explosive couplings, a runaway toolkit, flecks of paint and anything else that does not serve a human-derived purpose in orbit. The kinetic energy involved in impacts between space objects is so great that the destruction of useful space systems from collisions is always a possibility. Even if there were an end to satellite launches tomorrow, it may not make a difference to the growth in the number of orbital debris in low-Earth orbit (LEO), where many spy and remote observation satellites are positioned.[13] Impact events increase the amount of debris in orbit, which in turn heightens the chances of more debris events in a cascading phenomenon. If this were to occur enough times, there may be a runaway growth in debris and a decrease in the utility of space for modern civilization. This is the Kessler Syndrome. Orbital debris takes a very long time to fall back to Earth – measured from decades to millennia. As a result, the debris population has continued to grow since the dawn of the space age.

In 2007, the People's Liberation Army tested an anti-satellite (ASAT) missile on one of China's satellites. The event increased the amount of debris in orbit below 2,000 kilometres (km) by one fifth.[14] The Russian satellite Cosmos 2251's accidental collision with an American Iridium satellite in 2009 created over 1,200 pieces of tracked debris.[15] The number of detected and tracked debris objects from these two debris events is over 5,500, and they make up 36 percent of all objects residing in or passing through LEO.[16] These numbers only include the debris that can be tracked by space surveillance networks (SSN) as part of SSA efforts, which are usually greater than 10 centimetres (cm) in diameter. Smaller pieces have proliferated even more, but are exceedingly difficult to track with contemporary space radar capabilities. The United States possesses the most capable SSN and the most comprehensive single debris catalogue on Earth; there is no comprehensive and publically available catalogue.

The Kessler Syndrome predicts that Earth orbit will become more heavily populated by debris even should all launches into space end immediately. This is not to degrade the significance of

the adoption of debris mitigation guidelines, such as those put forward by the Inter-Agency Space Debris Coordination Committee (IADC),[17] but mitigation alone does not resolve the problem envisaged by the predictions of the Kessler Syndrome.

> Recent numerical simulations on the evolution of orbital debris population in low-Earth orbit (LEO, 200–2000 km altitude) indicate that the population has reached a point where the environment is unstable and population growth is inevitable. The main conclusion from the two studies is that even if no further space launches were conducted, the Earth satellite population would remain relatively constant for only the next 50 years or so. Beyond that, the debris population would begin to increase noticeably due to the production of collisional debris.[18]

If the forecasts are correct, and should the Kessler syndrome be realized, the space powers of the 2060s will begin to see a runaway growth in the number of collisions and debris in LEO. Liou and Johnson studied the effectiveness of four scenarios ranging between no action taken, and five, ten, and twenty objects removed per year from 2020. Removing as few as five troublesome debris objects every year from 2020 will mean that the large debris population at the dawn of the 23rd century may be halved from approximately 60,000 to 30,000.[19]

Space will become a much more hazardous environment for space operations, including force enhancement, treaty verification, and global communications; debris is a clear risk to military capabilities and provides some justification for including debris as a threat to national security. ADR systems do not exist as of yet, but they may be present in the years ahead. It is particularly important to remember when we consider the dual-use potential of ADR systems that ASAT weapons can have political effects even when they are only on the drawing board.[20]

ADR works through accelerating the natural decay process with pieces below 10 cm in diameter, and rendezvous operations with larger pieces.[21] Rendezvous operations could be done either by dedicated satellites or a satellite that launches smaller propellant modules to attach to targeted debris. Some systems envisage more exotic methods, such as Japanese plans for electrodynamic tethers,[22] and the European Space Agency (ESA) has commissioned studies on the feasibility of using netting and tentacles.[23] It is evident, then, that scientific minds across the world are researching, and some agencies are promoting, ADR systems. An American technological monopoly on ADR systems cannot be relied upon.

Despite the myriad different ADR proposals, all ADR systems need to physically interact with objects in space. Dual-use capabilities are evident in that an ADR system is not inherently restricted to targeting debris – working satellites could also be targeted. The crux of the matter is in the politics surrounding ADR systems and not in the technical workings or economic feasibilities of particular ADR systems. How these systems factor into space security considerations will next be considered in the conceptual argument for keeping security more traditional in space.

SPACE SECURITY

Securitization

Columba Peoples rightly declares that the space weaponization debate misses the wider dynamics and understandings of space security.[24] Securitization is proceeding virtually unchallenged within academia. Debating whether the weaponization of space serves any security interests or not often relates to what one thinks space security means.[25] Those in favor of making space a sanctuary tend to adopt a widened referent point of security (the international system or the space environment itself, with non-military risks treated as security threats), and those who favour, or do not wholly oppose, the weaponization of space (placing weapons in space) tend to concentrate on the political-military threats to U.S. space systems. Arguments over the weaponization of space become a debate unknowingly gravitating around competing and often unquestioned definitions of space security. Strategists may think in terms of net military advantages and threats for a state or alliance; "security wideners" may focus on environmental risks and other hazards beyond the focus of a particular state. It is into this uncritical and unreflective gap in space security literature this study now goes.

This gap lies between (a) scholars from a general Strategic Studies approach who focus on competing national or state securities and the problems posed by other political entities, and (b) scholars who widen their meaning of security and have a more Critical Security Studies bent, as exhibited in the examples below with human security and the broadening envisioned by the Copenhagen School. Illuminating this gap may allow the academic community discussing space to engage with each other through understanding and critiquing their competing interpretations of security.

Securitization theory partly guides this inquiry. Security is considered to be a speech act on behalf of a voice of authority[26] – in this case, both the U.S. government and academia. It is within the U.S. government's power to deem orbital debris a security issue and mobilize resources to tackle the threat posed by rogue paint flecks and rocket boosters. By securitizing orbital debris, academics can heighten its salience and imply that extraordinary means are required. Such moves may trigger unilateral American policies, and break established norms if ADR systems are perceived as ASAT weapons.[27] However, one need not subscribe to Buzan, Waever, and de Wilde's entire theory of securitization to use its principle to understand how non-military threats are being framed as security issues. For example, the assertion that a security label precludes political debate is rejected.[28] Defense policy is not inherently above the realm of politics, as the endless debate about strategy and national security in Western academic and journalist circles amply demonstrates. However, an issue framed as national security may indeed reduce the number of assumptions underlying government policy that are open to critique.

It is only attempts at securitization that are analyzed, as the establishing of who are the actors, audiences and to what extent the speech acts have succeeded in securitization does not address the question asked. Although this project is inspired by Waever's securitization and desecuritization,[29] it does not follow the process of desecuritization theory through to the letter by attempting to measure the success of securitization. Foregoing audience reception and only looking at the speech acts from government and academia is no weakness in this study. The academic elites' arguments over U.S. space policies need to be analyzed, as security is a concept which is not addressed to any sufficient degree. It may be the case that runaway space security widening is a symptom of political aspiration, rather than analytical clarity.[30]

Traditional Security

> Critics normally address the *what* or *who* that threatens, or the *whom* to be secured; they never ask whether a phenomenon *should* be treated in terms of security because they do not look into "securitiness" as such, asking what is particular to security, in contrast to non-security, modes of dealing with particular issues.[31]

What is security? What is to be secured? These two questions' answers help address the central concern: should orbital debris be considered a security issue? Similar to the under-analysis of the term space security, the concept of security itself may be under-conceptualized.[32] Although one may share Buzan's logical assertion that the word security should mean more than a situation of any kind of threat to any actor or value, the kind of broadening and deepening seen in *Security: A New Framework for Analysis* is what is being argued against in this paper.[33]

For this analysis the United States is the referent object of security in a traditional concept, with its space-dependent military capabilities and related satellite systems as physical manifestations of this statist referent object. This does not preclude the opinion that in ideal terms a state, such as the United States, should exist to serve its citizens; the state's security may be a means to an end, not an end in and of itself. Framing a problem as a security issue usually means that a threat could escalate into an issue of survival, if it may not be one already.[34] It may be difficult to escalate the issue of debris to one of survival, as opposed to general high-intensity conventional and nuclear war. Such a war may involve a sudden loss of many space assets in a concerted assault, whereas debris may neutralize individual satellites in a staggered and long-term fashion.

U.S. space security should be about securing American military and commercial satellites and U.S. capabilities to access and use space for the ends of its policies, from the threat of the denial of these space systems from another political entity. Rather than interpret any disruption to U.S. satellites as a security issue, it is the intentional disruption, destruction or negation of satellites by a political adversary that constitutes a threat to U.S. space security. Intentional here means the intent to field such weapons; the possibility of accidents and unintentional firings of weapons is not discounted. Although national security is a subjective concept laden with values,[35] the term security conjures images of the state securing itself from the threats it perceives from other armed political or violent entities on Earth:

> …security… carries with it a history and set of connotations that it cannot escape. *At the heart of the concept, we still find something to do with defense and the state*. As a result, addressing an issue in security terms still evokes an image of threat-defense, allocating to the state an important role in addressing it.[36]

However, strategic studies and Clausewitzian understandings of war are not limited to the state, as argued elsewhere.[37] Rather, the word security in practice has inescapable connotations with the state. When dealing with policy problems or pressing issues in any given domain in empirical reality, how we think of, conceptualize and operationalize security can have significant impacts on humans and the systems we depend upon. An example that comes to mind is the security-development nexus; how human development policies have become counterinsurgency

operations through securitization.[38] Discussing the meaning of security matters, particularly if one can foresee different policies, outcomes, dangers or opportunities emerging from them.

Broadening and Deepening Security

Some academics have been generous in their widening of security when discussing space security. James Moltz presents a compelling historical narrative of the Cold War space powers' military restraint from overtly testing and deploying weapons in space due to their ability to learn about the harmful environmental consequences of doing so.[39] Moltz is correct to stress the importance of the space environment, as it constrains or enables the very actions and purposes space actors have in using it in the first place. However, Moltz uses this environmental significance to understand (offensive) military restraint to argue that an "environmental security" approach as the most useful framework for understanding the past, present and future of politics in space.[40] Moltz believes that the referent object in space security should be the space environment itself.[41] This is deepening security beyond a state, as the environment in space affects all users of space and is characterized by transboundary problems, which are beyond the control, and perhaps remedies, of a single actor. It is no surprise that Moltz also broadens the term space security beyond traditional military conceptions of security:

> Space security depends on overcoming both man-made and natural threats… Space security [is] the *ability to place and operate assets outside the Earth's atmosphere without external interference, damage or destruction*.[42]

Therefore, anything that can disrupt or destroy satellites is a security concern in space to all space actors. Aside from a relatively brief mention of the transboundary nature of environmental space issues, Moltz does not engage in a conceptual discussion of environmental security or Critical Security Studies approaches.

Nevertheless, common thoughts between Moltz and environmental security concepts are apparent. In environmental security, the referent objects of security are "the planetary attributes necessary to sustain civilization."[43] This resonates with the resources of outer space, as space systems provide the everyday life of citizens of developed and developing countries with essential services. 'Space resources', such as clean orbits to place satellites in, enable much of modern military and economic power. Given the disadvantage militaries and economies will be at should space systems be degraded or disabled, it is easy to make an issue, such as debris, a security issue given that space is a part of critical infrastructure.

Elsewhere, Moltz makes an analogy of increasing space traffic and usage with the explosion in rail travel in the 19th century, and the standards of time, safety and conduct, which it brought with it, to imply that space is now at a similar point. The many powers and actors that use space may need a broader and common definition of space security to operate safely in space.[44] However, the management of rail networks was not done under a security rubric in the 19th century, despite their utility for mobilization. The lack of a conceptual interrogation of security allows such contradictory views and analogies to be used without opposition.

Cascading onwards, Nancy Gallagher too does not discuss the foundations of her own global and universal conceptions of security in any great detail. Importantly, she argues that space debris should be considered a security issue because achieving cooperation on space endeavours outside the security realm would remain isolated and perhaps ignored.[45] For Gallagher, a securitized cooperative approach to tackling space debris may spill over into more cooperative ventures in space security. Interestingly, Kiran Nair argues the opposite; making headway in non-military aspects of space security may spill over into cooperation, and thus, more sensitive military space issues.[46] However, Nair also broadens her conception of security by speaking of non-military aspects of space security. In a traditional security concept, there would be no aspect of space security that is not political-military. But, there would be dangers to space assets that would not be considered security threats.

Xavier Pasco and Bertrand de Montluc exhibit two more cases of widening space security by referring to the European Union's (EU) 'balanced' and 'holistic' approach to space security. Pasco believes many policy problems that face the EU cannot be addressed only through military approaches, and must be dealt with by means of a security-orientated policy that is not preoccupied with the military.[47] Military and security are two terms that appear to have very separate meanings for Pasco – tackling a problem like space debris may increase collective security for all in space, as opposed to some military policies that may jeopardize collective security in space. Unfortunately, the specific meanings of Pasco's or Montluc's military and security are unclear. Pasco's conception of military may address offensive capabilities by adversaries, and the security is a general adoption of the *Space Security Index*'s broad meaning of space security. This is problematic when there may be inescapable statist connotations to security.

Rajeev Lochan slightly adjusts the *Space Security Index* definition of space security to mean "secure, sustainable, and denial-free access to and use of space for peaceful purposes and for one and all."[48] Zhong Jing wishes for a new security concept to be developed for outer space, as the zero-sum security concept he accuses the United States of employing is jeopardizing everyone else's security in space. Further, Jing claims that conceiving of an enemy as the main threat in space will result in no progress and greater risks in orbit, whereas (deductively), Jing believes that the main threats to the space security of all actors comes not from enemies, but perhaps the environment and the pollution human activity is depositing there.[49] Exhibiting a similar tendency, D. Narayana Moorthi attempts to use human security to broaden and deepen a concept of space security:

> [Using the concept of human security] enables a broadening of our notion of space security from its traditional conception in military terms, to encompass other threats (including those emanating from poverty, lack of education, health hazards, environmental degradation and natural disasters). It also emphasizes that we deepen the concept of security from the state down to the individual level and up to the regional and international level.[50]

Using human security, then, allows non-military threats to peace and security to be alleviated with space systems, which provide development tools that may improve human security capabilities. It is no revelation that space systems are key tools in human development. However, whether development through space should be securitized is a question that is not addressed by Moorthi.

Desecuritizing Space Safety

Space development is a theme touched upon by Moltz; space should be developed, rather than defended or secured.[51] This appears to be a move away from securitizing outer space activities. Moltz's opinion here is in contradiction to his main argument above. How can one call for an environmental security concept as a useful foundation for understanding the politics of space whilst at the same time encouraging space activities to be viewed as standard development practices? Rather than securitizing many or all aspects of space activity, perhaps space should indeed be desecuritized, or at least space security should instead only refer to the political-military (i.e. strategic) challenges posed to one's own space systems by other space powers and vice versa.

Daniel Deudney warned that appending security onto environmental issues may serve as an attention-grabbing device with unfortunate consequences. Thinking in national security terms about environmental issues risks forcing an organization equipped to deal with threats from violence to engage with a different kind of threat: one posed by environmental hazards where zero-sum or self-serving statist thinking may not be the best way to address such problems.[52] Two points raised by Deudney strike a chord when assessing Moltz's use of environmental security: first, it is analytically misleading to think of environmental degradation as a national security threat because the traditional focus of such thinking has little in common with global environmental problems and their solutions; and second, mobilizing an awareness of environmental problems through the emotive power of nationalism may be "counterproductive by undermining globalist political sensibility."[53] In other words, nationalism may increase the chances of unilateral action with unwanted negative reaction by other actors.

Indeed, Moltz attempts to pry his version of the concept of security away from a single state as a referent point, and loosely refers to orbital space itself and all states and actors in the space environment as referent objects of security. However, if Waever claims that security has certain connotations that it cannot escape, Moltz's attempt at securitizing the space environment and the threats it contains may indeed backfire along Deudney's logic. This would be risky if future U.S. national security space policy was to adopt Moltz's views and incorporate space debris as a national security threat, and potentially take its own unilateral action in spite of international fears, suspicions and doubts. This becomes increasingly worrisome if ADR systems are introduced to the problem of space debris, as unpopular unilateral action with ADR systems may not reassure other space powers, which may see it as a cover for ASAT weapons deployment.

Moltz is not the only scholar to unwittingly call for desecuritization. Joan Johnson-Freese asks whether protecting satellites with technology is a viable means to an end for the United States.[54] Her policy prescription encourages the United States to rely on diplomatic, political and legal maneuvers to outlaw attacks on satellites and the technologies that enable them.[55] This better serves U.S. space security, and the conception of security at that point of her argument falls easily within a traditional framing. Again, a discussion of security itself is largely absent. This is unfortunate as later in her argument Johnson-Freese begins to simultaneously deepen space

security and exhibit a desire to desecuritize space by preferring the term "space sustainability" in the context of the globalized and largely peacefully-intended uses of space today.[56]

Some academics tend to retain their definitions of space security, or security in space, to the military realm. Scott Beidleman discusses the Galileo versus Global Positioning System (GPS) debate in terms of Galileo's potential threat to U.S. national security, arguing that Galileo is a manifestation of the EU's desire to acquire security apparatus independently of the North Atlantic Treaty Organization (NATO).[57] Peter Hays mostly adheres to a traditional security approach despite a passing reference to sustainable space security, as his book mostly focuses on political-military threats to U.S. space activity.[58]

Gerard Brachet argues that space access and a safe operating environment are not only defense issues; they are directly relevant to all uses of space. As civilian and military users all share the same orbital paths, it may be beneficial for them to jointly develop "rules of the road," a code of conduct, for the benefit of all kinds of space actors of all state origins.[59] This logic can be taken further by explicitly referring to space safety as a distinct concept separate from space security. "Space safety is a concept similar to space security, but the focus is placed on the measures to accomplish safer conduct in space activities by various methods."[60] A space traffic management (STM) system can be an example of space safety measures, defined as "the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from [inadvertent] physical or radio-frequency interference."[61] Passing measures for space safety may not require arms control treaties or proposals, thus circumventing deadlock at the Conference on Disarmament (CD) and the Committee on the Peaceful Uses of Outer Space (COPUOS).[62]

Among security wideners, the tension between widening security on one hand, and pushing for a developmentalisation of space activities on the other hand, is possibly a result of the complacency among the academics cited here with their conceptions of security. Without reflecting on the use of the term security, one can unintentionally follow Waever's logic of securitizing problems and end up wishing to desecuritize them after intuitively realizing the dangers of self-interested national security thinking in a domain where every actor's actions can easily adversely affect the other. Perhaps this desire to refer to global space activities through developmental terms is a result of the lack of a concept of international security.[63] Moltz and Johnson-Freese demonstrate this as they appear to step back from a widened security concept due to their inability to escape the connotations of the state, defense, force and self-interest that may accompany the term security.

One cannot disagree with desires to see a safe operating environment in space for all users if one has no radical transformative agenda. Therein lays the crucial word: safety.[64] Environmental degradation poses a risk to the safe operation of assets in space. Putting unintentional environmental hazards into the same mental framing as intentional targeting of satellites for strategic reasons conflates the differing issues at hand and risks the conflation of space development and security interests in orbit.

The pursuit of space security should be taken to mean an state's attempts to protect its access to and use of space and the relevant satellite systems from possible intentional threats by other

actors. Now that an understanding of the Kessler Syndrome and ADR proposals is at hand, and an argument for the meaning of security to stay traditional explained, combining the two cascading phenomena demonstrates how questioning concepts of security helps provide an approach to deal with the problem of debris and the duality of ADR in a more politically amiable manner.

DUALITY

This section tests the hypothesis that using a widened concept of security in space endangers the potential of ADR systems to ameliorate the burden of orbital debris. This is an anticipation of the politics of ADR systems, and ideally serves as a preventative argument against any supporter of ADR systems attempting to justify action against debris on the grounds of national security. This is done through building upon the counterargument (mentioned earlier) against widening the term space security, which is so often used but seldom analyzed.

Each particular kind of ADR system is designed to interact with objects in orbit in one way or another by altering their orbital paths. All ADR technologies can be construed as systems capable of targeting and interfering with operational satellites, as well as debris. There are two major political challenges surrounding ADR – their development and operation.

First, ADR systems from the conceptual and development stage onward run the risk of being seen as ASAT weapons by external actors. Space weapons may bear a large political significance beyond "just another weapons system."[65] If an American ADR system is viewed as an ASAT weapon system in China, the diplomatic and political fallout may be costly; it is not unreasonable to expect political costs following ASAT weapons deployment in light of Russian and Chinese initiatives via the draft treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects (PPWT).[66] The PPWT aims to ban all weapon placements in space, going further than the 1967 Outer Space Treaty (OST), which bans only the placement of "weapons of mass destruction" in space.[67] Curiously, the PPWT does not ban Earth-to-space weapons, as it defines space weapons as weapons based in space.[68] Earth-based weapons targeted at space can be categorized as space weapons if we define them as any system whose use destroys or damages working satellites in or from space. This definition paraphrases Moltz's, but crucially changes the word "object" of the PPWT to satellite.[69] By this definition, the PPWT would not ban all space weapons – and would not affect extant space weapons, such as pre-existing American and Chinese kinetic-kill missiles and Earth-based lasers.[70]

The word object in the PPWT also raises the possibility of banning ADR systems as their behavior and technology is almost identical to ASAT weapons if a distinction is not made between systems that target working satellites and debris. Therefore, space weapons should be defined in separate terms to that of ADR systems so that ADR systems are not consigned to the same restrictions as ASAT weapons from any potential PPWT-style treaty in the future. A practical distinction is not impossible as civil space programs use rendezvous and docking technology – such as resupply modules to the International Space Station and the now retired Space Shuttle satellite repair and servicing capabilities. As a side-note, ground-based laser orbital

debris removal systems may be less politically sensitive if Russian and Chinese definitions of space weapons do not change, but may not be as effective in removing the largest and most troublesome debris objects. However, any such laser system, which was capable of removing large objects, could easily alter the orbits or even disable functional satellites in LEO.

The second political challenge posed by ADR systems is in their operation. The models for projecting the debris population after ADR operations begin are based on categorizing certain debris objects that are most likely to cause more debris-generating events. These models do not take into account the politics of removing such objects. Most debris is owned by the United States, Russia and China.[71] There are legal difficulties surrounding ADR, including the lack of mandatory debris registration and cataloging, infringement of intellectual property via close scanning and the lack of a liability regime for debris events.[72] The political difficulties of operation arise from the imbalance of debris ownership coupled with the prioritization of debris removal (object mass times collision probability), which would make any ADR attempt along such mathematical guidelines alone highly politically motivated. Since there is no obligation of declaration of debris, an ADR system could remove what may appear to be a defunct satellite, but could turn out to be a dormant satellite with ulterior purposes.[73]

Widened Space Security Versus Traditional Space Security

These two problems of the development and operation of ADR systems are significant enough before we consider how a widened concept of security can exacerbate them. On the one hand, there is a traditional security concept where the pursuit of space security should mean an actor's attempts to protect its access to, and use of, space and the relevant satellite systems from threats by other actors in space; and on the other hand, there is a widened notion of space security, which means any risk to all uses and users of space is a security threat and urgent steps should be taken to address these security concerns.

If we first apply the widened space security approach to a U.S. space policy perspective, orbital debris is considered a security issue for every actor as it threatens the reliable access to and use of space. The argument could be made that orbital debris will threaten the national security uses of space for all actors and will require urgent action to remediate the situation. There is some merit in this argument – a large enough piece of debris may have similar consequences as a kinetic-kill vehicle in an ASAT weapons system. Indeed, there is congruence between a nationalist conception of emergency (albeit measured over decades) with the need for action, and a globalist environmental position on orbital debris with alarming visions of the future environment.[74]

Even so, as argued above, using the national security lens may be counterproductive according to Deudney's logic. Using a widened security concept may not work even if the deepened referent point of security was carried through in security policy. Environmental hazards in space have pushed numerous scholars to refer to humanity as a whole or all space actors as the referent points of their widened space security concepts. It is true that environmental hazards in space are threats to all spacefaring actors, and Deudney captures well how this logical widening of space security's referent point came about:

> … existing 'us *vs.* them' groupings in world politics match very poorly the causal lines of environmental degradation. At its most basic level, the environmental problem asks us to redefine who 'us' encompasses. Coping with global problems and new forms of interdependence requires replacing or supplementing national with other forms of group identity.[75]

In theory, widening may be logically sound. In practice, there are risks to attaching the word security to what is a global problem. An American belief that it is acting on behalf of all space actors' "space security interests," or even the space environment, may be difficult to convey without foreign suspicion because ADR systems can be seen as ASAT weapons.

National security bureaucracies may contaminate ADR removal protocols by determining, according to their own calculi, which debris objects are more likely to interfere with their own satellites, rather than the objects which would pose a greater risk of increasing the debris population and present a more immediate threat to another actor's satellites or orbital paths. Conversely, a choice could be made not to remove debris which poses a more immediate threat to a potential adversary or the other party in a political dispute. Securitizing debris may elevate *or even lower* the priority of the solutions needed for the Kessler Syndrome, but only on a self-interested national basis, rather than a non-discriminatory global commons approach. Environmental issues, such as orbital debris, may require "behaviour modification in situ," rather than using a defense organization.[76] Human behavior needs to change by introducing routine orbital clean-up operations; this is contrary to the possible effect of securitization – exceptionalizing measures when they should be routine.[77]

What this means for orbital debris' solution is that ADR systems – as part of a transparency and confidence building measure (TCBM) to alleviate fears over the duality of ADR – should be more open and not locked away in the bowels of the American military-industrial complex with departments like the Defense Advanced Research Projects Agency (DARPA). Securitizing debris may push ADR systems down the path of defense procurement, which may exacerbate fears over the duality of such technological research to the other space powers. One can easily maintain a sceptical attitude towards the possibility of U.S. security policy discourse deepening its referent point of security; there may only be a broadening of security in space to include non-military risks, but the referent point may remain tied to the U.S. state due to a naïve belief that U.S. security inherently confers security to everyone in the system.

Using the traditional concept of security helps to answer the question of whether orbital debris is better addressed through "normal politics" or "panic politics."[78] Normal is taken here to mean conditions of peace, or the absence of openly hostile behavior between two or more space powers. Conversely, a condition of war or an act of aggression is taken to mean panic politics, which is an abnormal or exceptional state of affairs. This helps fill a gap in Buzan's *Security: A New Framework for Analysis* by defining a possible condition of normality. Orbital debris is not addressed by a traditional security concept in space. Orbital debris does not come into the space security threat analysis under a traditional concept of security as orbital debris is unintentional and indiscriminate.

Traditional space security would be more concerned with strategic studies and the conduct of military operations in, from and through space. Geographical and environmental factors should

be taken into account – but that does not lead to a widening of space security or security in space for the United States. Indeed, any sound strategic planning and analysis has to take into account the geographical and environmental context.[79] An aversion to the risks generated by debris events, borne of an appreciation for the environmental risks of space warfare with hit-to-kill ASAT weapons, may force space warfare down the path of ground-based laser blinding, jamming and cyber operations to disable, de-orbit and hijack satellites. If space warfare goes down such an environmentally cleaner path, debris may become a problem more associated with routine operations in space, and not traditional security matters at all.

By keeping space security focussed on strategy, conflict and the traditional connotations of security, orbital debris and ADR systems may be seen as space development issues, rather than security ones. Space development here means the pursuit of greater, cheaper, safer and more reliable access to space, for all uses of space, including military, scientific, economic, observation and so forth.[80] Orbital debris is not just a risk for the national security purposes of space, but for all uses of space.[81] This brings back the notion of normality to the debate over securitizing orbital debris. Just the same as utilizing SSN for the safety of space assets to avoid collision is a routine operation, removing debris from orbit should also be a routine operation.

This normative assertion can be elaborated through a hypothetical scenario where space is a sanctuary from warfare.[82] Even in this scenario, orbital paths around Earth would still become polluted – the debris population has been increasing for decades in the absence of overt military confrontation. Pollution would still be occurring in orbit regardless of the military significance an actor may be attaching to it. If polluting orbits is a normal and routine consequence of all human activity in outer space, cleaning up space should also be a routine operation to preserve the continued utility of space. If ADR operations can be routinized and regulated among the space powers, the myriad legal ambiguities and difficulties can plausibly be overcome via a code of conduct or similar memoranda of understanding that do not rigidly insist on including clauses about ASAT weapons.

However, if debris is not considered a security issue, it may not get the funding attention it needs. Lobby groups in the United States may indeed want to attach security to raise its political profile to get ADR systems the funding and action needed to develop them.[83] This may be a problem posited by the American policy making environment, as the presentation of environmental problems as threats rests on a recurrent conflation of threat with risk. Environmental security may be a symptom of the highly politicized assessment of risk in U.S. policy making, rather than a relatively more objective account of non-political risks. To contextualize, Barnett claims that threats posed by politically motivated actors in space are conflated with routine risks of operating in the space environment. [84]

An Impasse

There appears to be an impasse between the arguments for and against the widening of space security. Widening space security, to securitize orbital debris, appears to be able to confer a heightened prominence to the risks of debris and to policy makers to move ahead with ADR development in a sense of urgency. Meanwhile, at the other end of this impasse, keeping space

security traditional allows the military industrial complex to stay in its defense and traditional security domains and concentrate on the threats of politically-motivated hostilities. This allows space debris to be categorized as something routine, and as a result ADR systems can be viewed as a necessary part of sustaining the viability of space for the uses of human civilization – something more akin to a development problem.

At first glance, this may not seem like much of an impasse, or at least an inconsequential one. A widener of space security may ask does it matter how it is viewed? If it gets the funding, why not attach space debris onto the space security agenda? The intentions are agreeable; action is needed. However, when the problems of duality and the risks of security policy's contamination of an environmental issue are realized we can appreciate the significance of this impasse, and a possible resolution.

Securitizing space development may put too much political self-interest on the part of the space powers for something that should be done in normal conditions. Like air and maritime traffic, global regulations exist for the efficient and safe passage of civilian and military vessels. Atmospheric turbulence or turbulent seas may not be considered security threats; why should environmental disturbances in space be any different? Securitizing space debris may attempt to make the normal, or needed behavior to manage human space systems, exceptional. Securitizing space debris may make unilateral national-security action more palatable for policy makers and a hostile response to the dilemma of interpretation more likely. However, transparency in ADR development may not alleviate fears, but only incite further suspicion.[85] Transparency must accompany confidence in any concerted effort to alleviate international suspicions.

It is worth asking here if ADR systems should be developed in a panic political mode as Earth's space powers could view a hasty ADR development as a cover for ASAT weapons. Some ADR techniques have been present in ASAT weapons programs concepts, such as on-orbit servicing and rendezvous. The military funding and general secrecy of development surrounding technologies associated with SSA and ADR serve to fuel paranoia from abroad and casts doubts over technology sharing.[86] Another risk of securitizing debris and ADR systems is that the PPWT may be pushed even further by Russia and China as an attempt to stall a perceived U.S. attempt at weaponizing space. Moreover, securitizing debris risks banning space-based systems from interacting with satellites for repair or debris for benign purposes.

If widening space security carries these risks, does keeping security traditional reduce the risks of negative political consequences for an American ADR deployment? Widening space security is not certain to result in greater dual-use fears over ADR development, but it increases the risks of it happening. Conversely, even if debris is not considered a security issue, the problems of operation still exist and may trigger diplomatic crises should customary or written laws not be created.

Taking the security out of the orbital debris debate allows a sustainable development point of view to grow – the United States could frame its ADR in development terms and stress its 'good space service provider' credentials. A certain degree of openness may be required as part of a TCBM gesture. Unlike a weapons system that may need a constant global presence in space for missions, such as space blockade,[87] an ADR system need not necessarily be the same. Taking out

as little as five troublesome debris objects per year, coupled with legal agreements on removal forged between the three most polluting space powers, means that such a small number of ADR events could be regularized – indeed normalized. Such a system could be notified to all users of space, and one ADR satellite could not pose much of an immediate threat should its owner have hostile intentions. Regular timetables for ADR could earn the acceptance of the other space powers should the United States deploy and operate ADR systems. Indeed, a routinization of ADR operations is what Deudney refers to as "behavior modification in-situ"[88] – human behavior needs to change from its present shape and begin to clean up orbit.

CONCLUSION

Widening space security may be risky because the intended referent point of security amongst academics may not be carried through into security policy making in the United States, or any other state. A self-interested and unilateral approach to debris and ADR systems may exacerbate concerns over the duality of such systems and may result in greater efforts by other space powers to ban the technologies that both ASAT and ADR systems depend upon. In contrast, desecuritizing debris and ADR systems may result in some chance of reassuring the other space powers over genuine benign intentions with ADR systems by making such numerically small ADR operations routine (which are feasible) for any spacefaring actor. Keeping space security traditional improves the chance of a routinization and normalization of ADR activities. Space debris is a normal consequence of humanity's routine use of Earth orbit. Panic politics and securitization may not be the best way to approach debris and ADR systems; space development is a growing approach to outer space, particularly with the emergence of private companies planning to either provide access to space or harvest potential economic bounties from the solar system.

When considering an all-encompassing view of human activity in space, it should not be one of "global space security" as is so often seen in academia. It is space development or space safety – like regulating air and maritime traffic or venturing to a distant continent for mineral riches. In addition, this paper has elaborated upon a gap between strategic studies and the wider body of security studies' literature on space and the debate on weaponization. Identifying the concepts of security used in any argument on weaponization will hopefully further understanding and healthy debate. Moving issues crucial to the sustainable management and use of space away from the deadlock over space arms control at the United Nations may prove essential to allowing ADR systems to flourish. Space security should remain in its strategic studies heartland, and should not boldly go into the realm of non-military and routine risks to space systems. It is hoped that this argument may trigger some self-reflection among academics (at least) and policy makers (at best) with regard to their use of the concepts of security with the crucial and often used but seldom analyzed term, space security, lest we as a species close off space to any further useful development because of our polluting activities.

ACKNOWLEDGEMENTS

The author would like to thank Dr Jan Ruzicka and Mr James Chisem for their help in writing this article.

NOTES

[1] Eligar Sadeh and Brenda Vallance, "The Policy Process", in Damon Coletta, Frances T. Pilch eds., *Space and Defense Policy* (Abingdon: Routledge, 2010) pp. 125-127
[2] US Government, "National Space Policy of the United States of America", 28/06/2010, Washington, D.C., available online: http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf (accessed 02/07/2012) 1-3
[3] Ibid., 4
[4] Ibid. Italics added.
[5] Cesar Jaramillo ed., *Space Security 2011* (Kitchener: Pandora Press, 2011) Available at www.spacesecurity.org, (accessed 24/05/2012), 7
[6] US Government, "National Security Strategy", May 2010, Washington, D.C. Available online: http://www.whitehouse.gov/sites/default/files/rss_viewer/national_security_strategy.pdf (accessed 02/07/2012), 50
[7] Ibid., 1, 4-5, 33, 39, 47
[8] US Department of Defense (DoD), "National Security Space Strategy: Unclassified Summary", January 2011, Washington, D.C., available online: http://www.defense.gov/home/features/2011/0111_nsss/ (accessed 24/05/2012), 1. Italics original.
[9] Ibid., 1-2
[10] Ibid., 6
[11] US DoD Directive 3100.10, "Space policy", 18 October 2012, Washington, D.C., http://www.dtic.mil/whs/directives/corres/pdf/310010p.pdf (accessed 25/11/2012)
[12] Michael Listner, "Legal issues surrounding space debris remediation", *The Space Review*, 06/08/2012, http://www.thespacereview.com/article/2130/1 (accessed 17/08/2012)
[13] J.-C. Liou, N.L. Johnson, N.M. Hill, "Controlling the growth of future LEO debris populations with active debris removal", *Acta Astronautica* (66, 2010), 648
[14] Jaramillo, *Space Security 2011*... 30
[15] Ibid., 31
[16] National Aeronautics and Space Administration (NASA), *Orbital Debris Quarterly News* (16:3, 2012) http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv16i3.pdf, 2
[17] Inter-Agency Space Debris Coordination Committee (IADC), "IADC Space Debris Mitigation Guidelines", IADC 02-01, September 2007 http://orbitaldebris.jsc.nasa.gov/library/IADC_Mitigation_Guidelines_Rev_1_Sep07.pdf, (accessed 15/07/2012.)
[18] J. C. Liou, Nicholas L. Johnson, "A sensitivity study of the effectiveness of active debris removal in LEO", *Acta Astronautica* (64, 2009), 236
[19] Ibid., 238-239
[20] Joan Johnson-Freese, *Heavenly Ambitions: America's Quest to Dominate Space* (Philadelphia: University of Pennsylvania Press, 2009), 67
[21] On ADR methods, see: Brian Weeden, "Overview of the legal and policy challenges of orbital debris removal", *Space Policy* (27, 2011), 39. Original table from: Olympio J, Summerer L, Naja G, Leitner J. Powerpoint presentation at the European workshop on active debris removal: "Towards a better understanding of active space debris removal options", vol. 22; June 2010. Paris, France.
[22] Satomi Kawamoto, Yasushi Ohkawa, Shoji Kitamura, Shin-Ichiro Nishida, "Strategy for Active Debris Removal Using Electrodynamic Tether", *Transactions of Space Technology Japan* (7:26, 2009)
[23] European Space Agency (ESA), "RObotic GEostationary orbit Restorer (ROGER)", http://www.esa.int/TEC/Robotics/SEMTWLKKKSE_0.html, last update 02/11/2011. (Accessed 30/07/2012)
[24] Columba Peoples, "The growing securitization of space", *Space Policy* (26, 2010), 206
[25] For example: Everett C. Dolman, *Astropolitik: Geopolitics in the Space Age* (London: Frank Cass, 2002), Sterling Michael Pavelec, "The Inevitability of the Weaponization of Space: Technological Constructivism Versus Determinism", *Astropolitics* (10:1, 2012), and Union of Concerned Scientists, *Securing the Skies*, November 2010. http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/policy_issues/ (accessed 10/12/2012)

[26] Barry Buzan, Ole Waever, Jaap de Wilde, *Security: A New Framework for Analysis* (London: Lynne Rienner, 1998), 27
[27] Ibid., 26
[28] Ibid., 4-5, 23
[29] Ole Waever, "Securitization and Desecuritization", in Ronnie D. Lipschutz ed., *On Security* (Chichester: Columbia University Press, 1995)
[30] Simon Dalby, *Environmental Security,* (London: University of Minneapolis Press, 2002), 9
[31] Ole Waever, "Securitization and Desecuritization"... 57. Italics original.
[32] David A. Baldwin, 'The Concept of Security', *Review of International Studies* (23:1, 1997), 8-12
[33] Buzan et al, *Security: A New Framework...*5
[34] Ibid., 24
[35] Arnold Wolfers, ""National Security" as an ambiguous concept", *Political Science Quarterly* (67:4, 1952) 481, 483
[36] Waever, "Securitisation and Desecuritisation..." 47. Italics added.
[37] Edward J. Villacres and Christopher Bassford, "Reclaiming the Clausewitzian Trinity", *Parameters* (Autumn 1995)
[38] Maria Stern and Joakim Ojendal "Mapping the Security-Development Nexus: Conflict, Complexity, Cacophony, Convergence?", *Security Dialogue* (41:1, 2010) 23
[39] James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Stanford: Stanford University Press, 2008, 1st edition) 46. For a review, see: Bleddyn E. Bowen, "Book review: The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests by James C. Moltz," *Intelligence and National Security Journal*, (28:2, 2013)
[40] Moltz, *The Politics of Space Security...* 7
[41] Ibid., 40, 44
[42] Ibid., 11. Italics original.
[43] Dalby, *Environmental Security...* 5-7. Dalby refers to: Richard Ullman, 'Redefining Security', *International Security* (8:1, 1983)
[44] James Clay Moltz, "Next steps towards space security", in John M. Logsdon, James Clay Moltz, Emma S. Hinds eds., *Collective Security in Space: European Perspectives* (Washington, D.C.: Space Policy Institute, 2007) 124-126
[45] Nancy Gallagher, "Towards a Reconsideration of the Rules for Space Security", in John M. Logsdon, Audrey M. Schaffer eds., *Perspectives on Space Security* (Washington, D.C.: Space Policy Institute, 2005) 1-3, 27 33, 38
[46] Kiran K. Nair, "Space Security: Reassessing the Situation and Exploring Options", in John M. Logsdon, James Clay Moltz eds., *Collective Security in Space: Asian Perspectives* (Washington, D.C.: Space Policy Institute, 2008) 85
[47] Xavier Pasco, "Enhancing Space Security in the Post Cold War Era: What Contribution from Europe?", in John M. Logsdon, Audrey M. Schaffer eds., *Perspectives on Space Security...* 57-60,and Bertrand de Montluc, "Space Security: A non-US point of view", in John M. Logsdon, Audrey M. Schaffer (eds.) *Perspectives on Space Security...* 80-81
[48] Rajeev Lochan, "Some Reflections on Collective Security in Space", in John M. Logsdon, James Clay Moltz eds., *Collective Security in Space: Asian Perspectives...* 34
[49] Zhong Jing, "China and Space Security", in John M. Logsdon, James Clay Moltz eds., *Collective Security in Space: Asian Perspectives...* 77-83
[50] D. Narayana Moorthi, "What 'Space Security' means to an emerging space power", *Astropolitics* (2, 2004) p. 263
[51] Moltz, *The Politics of Space Security...* 321
[52] Daniel Deudney, "The case against linking environmental degradation and national security", *Millennium* (19:3, 1990) 461-469
[53] Ibid., 461
[54] Johnson-Freese, *Heavenly Ambitions...* 2
[55] Ibid., 63
[56] Ibid., 133-135
[57] Scott W. Beidleman, "GPS vs Galileo: Balancing for position in space", *Astropolitics* (3, 2005) 119-120
[58] Peter L. Hays, *Space and Security: A Reference Handbook* (Oxford: ABC-CLIO, 2011) 79-81
[59] Gerard Brachet, "Collective Security in Space: A key Factor for sustainable long-term use of space", in John M. Logsdon, James Clay Moltz, Emma S. Hinds eds., *Collective Security in Space: European Perspectives...* 8-11

[60] Setsuko Aoki, "Japanese Perspectives on Space Security", in John M. Logsdon, James Clay Moltz (eds.) *Collective Security in Space: Asian Perspectives*... 52
[61] Ibid.
[62] Ibid.
[63] Waever, 'Securitisation and Desecuritisation'... 48
[64] However, this may be a problem and solution specific to English-language security studies. For example, in Welsh 'security' and 'safety' are often referred to by the same word – 'diogelwch' – which complicate matters further given different modes of thought and expression that may be apparent in different languages.
[65] Michael O'Hanlon, *Neither Star Wars nor Sanctuary: Constraining the Military Uses of Space* (Washington, D.C.: Brookings Institution Press, 2004) 21
[66] Victor Vasiliev, "THE DRAFT TREATY ON THE PREVENTION OF THE PLACEMENT OF WEAPONS IN OUTER SPACE, THE THREAT OR USE OF FORCE AGAINST OUTER SPACE OBJECTS", Published in Security in Space: The Next Generation—Conference Report, 31 March–1 April 2008, United Nations Institute for Disarmament Research (UNIDIR), 2008. http://unidir.org/pdf/articles/pdf-art2822.pdf (accessed 01/08/2012)
[67] United Nations Office for Outer Space Affairs (UNOOSA), "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies", http://www.oosa.unvienna.org/oosa/SpaceLaw/outerspt.html, (accessed 01/08/2012).
[68] Alexei Arbatov, "Preventing an arms race in space", in Alexei Arbatov and Vladimir Dvorkin eds., *Outer Space: Weapons, Diplomacy, and Security* (Washington, D.C.: Carnegie Endowment for International Peace, 2010) p.85
[69] Moltz, *The Politics of Space Security*... 43
[70]*The Economist*, "Satellite Wars: Endangered birds", in *Technology Quarterly*, Q4, 2010, 09/12/2010. http://www.economist.com/node/17647639 (accessed 01/08/2012)
[71] Kathy Jones, Krista Fuentes, David Wright, "A Minefield in Earth Orbit: How Space Debris Is Spinning Out of Control [Interactive]", *Scientific American*, 01/02/2012, http://www.scientificamerican.com/article.cfm?id=how-space-debris-spinning-out-of-control&WT.mc_id=SA_CAT_SPC_20120202# (accessed 01/08/2012)
[72]Weeden, "Overview of the legal and policy...", and Michael Listner, "Addressing the challenges of space debris, part 2: liability", *The Space Review* , 17/12/2012, http://www.thespacereview.com/article/2204/1 (accessed 19/12/2012)
[73] Weeden, 'Overview of the legal and policy...' 40-42.
[74] Deudney, 'The case against linking...' 466-467
[75] Ibid., 468
[76] Ibid., 464-465
[77]Dalby, *Environmental Security*... 10
[78] Ibid., 34
[79] David J. Lonsdale, *The Nature of War in the Information Age: Clausewitzian Future* (London: Frank Cass, 2004) 86-90, 94, 196, 203
[80] Nader Elhefnawy, "Economic growth and space development over the long haul", *The Space Review*, 29/09/2008, http://www.thespacereview.com/article/1220/1 (accessed 03/08/2012)
[81] Brachet, "Collective Security in Space..." 8
[82] John J. Klein, *Space Warfare: Strategy, Principles, and Policy* (Abingdon: Routledge, 2006) 16-18
[83] Dalby, *Environmental Security*...9
[84] Jon Barnett, *The Meaning of Environmental Security* (London: Zed Books, 2001) 89
[85] Ken Booth and Nicholas J. Wheeler, *The Security Dilemma* (London: Palgrave Macmillan, 2008) 4-6
[86] Brian Weeden, "Dealing with Galaxy 15: Zombiesats and on-orbit servicing", *The Space Review*, 24/05/2010, http://thespacereview.com/article/1634/2 (accessed 03/08/2012), and Brian Weeden, "X-37B Orbital Test Vehicle Fact Sheet", *Secure World Foundation*, 19/05/2010, http://swfound.org/media/1791/x-37b_factsheet.pdf (accessed 03/08/2012)
[87] Klein, *Space Warfare*... 29, 91-99
[88] Deudney, 'The case against linking...' 464-465